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MECHANICAL PROPERTIES, INCLUDING FRACTURE TOUGHNESS AND FATIGUE, CORROSION CHARACTERISTICS AND FATIGUE-CRACK PROPAGATION RATES OF STRESS-RELIEVED ALUMINUM ALLOY HAND FORGINGS

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Contract No. F33615-68-C-1385
Project No. 7381

Third Technical Management Report
August 15, 1968 - November 15, 1968

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ABSTRACT

Except for a few tests, the tensile, compressive, shear and bearing properties have been determined for all but three of a total of forty 2014-T652, 2024-T852, 7075-T7352 and 7079-T652 hand forgings scheduled for test. Ratios among these properties have been calculated. Plane-strain fracture-toughness values have been determined for two of the hand forgings. The results of axial-stress fatigue tests (R=0.0) of smooth specimens are presented.

The preparation of specimens for the stress-corrosion and exfoliation tests has been initiated, and exposure of the specimens will be started soon.

Tests of the 6x24-in. 2014-T652 hand forging are in progress to study the effects of notch geometry, specimen length and stress on the rate of fatigue crack propagation.

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Third Technical Management Report

MECHANICAL PROPERTIES, INCLUDING FRACTURE TOUGHNESS AND FATIGUE, CORROSION CHARACTERISTICS AND FATIGUE-CRACK-PROPAGATION RATES OF STRESS-RELIEVED ALUMINUM ALLOY HAND FORGINGS

I. Introduction.

The design mechanical properties, fracture toughness, corrosion characteristics and fatigue-crack propagation rates are four of the most important factors involved in the selection and efficient design of aircraft structures. Such data are needed for aluminum alloy hand forgings for several reasons: (1) much of the published design data has become obsolete by a change in the basis of specifying minimum properties, from one in which the length, width and thickness were considered, to one where only the thickness is involved; (2) the development of a technique of stress relieval by cold work in compression has resulted in relatively new tempers (TX52) for many of the alloys; and (3) there have been some significant problems with forged parts in recent years that were related to fracture and stress-corrosion characteristics.

Accordingly, the properties of hand forgings of several aluminum alloys currently being used in aircraft structures are being determined under this contract. The tests are intended to provide statistically reliable data for deriving design mechanical properties for MIL-HDBK-5A, including stress-strain and compressive tangent-modulus curves. In addition, data concerning the fracture toughness, axial-stress fatigue, stress-corrosion, exfoliation and fatigue-crack propagation rates are being obtained.

This Third Technical Management Report summarizes the results of tests carried out during the third quarter of the contract, and the general status of the program at this time.

II. Material.

All but one of the hand forging samples to be investigated have now been obtained. The 6x24-in. 7075-T7352 forging which had been received did not meet the tentative minimum tensile properties and was returned to the plant for reheat treatment. The reheat-treated sample is expected within the next month.

III. Procedure.

All the specimens and test procedures were described in the First Technical Management Report, dated May 15, 1968.

IV. Progress During Quarter.

A. Mechanical Properties

A.1. Tensile, Compressive, Shear and Bearing

Tensile, compressive, shear and bearing tests have been made of 37 forgings, the results of which are shown in Tables I through IV. The ratios showing the relationships among these mechanical properties are shown in Table V.

Since the data for the various sizes of hand forgings of any one alloy are not complete, no detailed analysis has been made of the test results.

A.2. Fracture Toughness

Notch-bend fracture tests have been made of two of the hand forgings. The average values obtained are as follows:

Alloy and Temper	Sample Cross-Sect. Size, in.	Sample Number	Sample Direction*	K_{Ic}, psi$\sqrt{in.}$
2014-T652	5x20	341013	LW	29 200
			WL	19 600
7075-T7352	4x16	341030	LW	32 700
			WL	26 500

The above values are considered to be valid, although for some individual specimens the stress intensity used in fatigue cracking was slightly in excess of 50 per cent of the K_{Ic} value, and the fatigue crack deviated from straightness by slightly more than 5 per cent of the thickness.

Specimens from most of the other hand forging samples have been prepared and are in the process of being fatigue cracked.

A.3. Axial Stress Fatigue

The axial-stress fatigue (R=0.0) tests of specimens from all except the 6x12-in. 7075-T7352 hand forging have been started, and approximately 80 per cent of the scheduled tests have been completed. The results of the tests are plotted in Figs. 1 through 4.

* The first letter indicates the direction of a line normal to the crack plane in the specimens; the second letter indicates the direction of crack growth. L - Longitudinal (major axis of forging); W - Width.

B. Corrosion Characteristics

Specimens have been obtained from sixteen of the twenty-three hand forgings scheduled for corrosion testing.

Specimens from the 2x8-in., 3x12-in. and 5x20-in. forgings have been machined, and it is expected that the stress-corrosion specimens will be exposed in late November, 1968. Specimens have also been prepared for exposure to the accelerated exfoliation test; however, due to the extensive backlog of specimens for this exposure, there will be some delay before the tests are started. Some of the specimens from the 4 and 6-in. thick samples have been prepared, but the testing is being delayed until all of the specimens from a given size of forging can be exposed concurrently.

Machined slices of the 6x6-in. 7075-T7352 and 7079-T652 forgings have been obtained for macroetching to determine the grain orientation. Preparation of specimens from these samples will be initiated shortly.

C. Fatigue Crack Propagation

Twenty long-transverse crack propagation specimens were prepared from the 6x24-in. 2014-T652 hand forging. Tests of these specimens have been initiated to study the effects of notch geometry, specimen length and periodic changes in stress on the rate of fatigue-crack propagation. The 6x24-in. 7079-T652 hand forging has been submitted to the Machine Shop for preparation of six additional specimens.

The program calls for evaluation of the effects of specimen orientation and humidity on the rate of crack propagation for two of the four alloys. It was originally indicated that the selection of the two alloys might be made when data comparing the propagation behavior of all four alloys was available. However, with the delay in receiving the forgings, this is not feasible. Thus, it is proposed that these tests be made on the alloys expected to show the greatest difference in resistance to stress-corrosion cracking; i.e., 7075-T7352 and 7079-T652.

V. Summary.

The tensile, compressive, shear and bearing properties determined for 37 of the 40 hand forgings scheduled for test are shown in Tables I through IV. The tensile properties of the hand forgings meet the applicable specified minimum-property requirements shown in Table VI. Ratios among the properties are as shown in Table V.

Notch-bend fracture toughness tests were made of two hand forgings, the average K_{Ic} values are shown in Section IV, A.2 of the text.

Approximately 80 per cent of the axial-stress fatigue tests have been completed. The results of the tests are plotted in Figs. 1 through 4.

Specimens from the 2, 3 and 5-in. thick forgings have been prepared and the stress-corrosion and accelerated exfoliation tests are to be started soon. Although some of the

specimens from the 4 and 6-in. thick samples have already been prepared, testing is being delayed so that all of the specimens from a given size of forging can be exposed concurrently. Machined slices from the 6x6-in. 7075-T7352 and 7079-T652 forgings have been obtained to determine the grain orientation.

Tests of the 6x24-in. 2014-T652 hand forging have been initiated to study the effects of notch geometry, specimen length and stress on the rate of fatigue-crack propagation. It is planned to evaluate the effects of specimen orientation and humidity for alloys 7075-T7352 and 7079-T652; these two alloys would be expected to show the greatest difference in resistance to stress-corrosion cracking.

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VI. Tables and Figures.

TABLE I

MECHANICAL PROPERTIES OF STRESS-RELIEVED 2014-T652 ALUMINUM ALLOY HAND FORGINGS

(F33615-68-C-1385)

SAMPLE			TENSILE				COMP.	SHEAR	BEARING‡ EDGEWISE			
CROSS-SECTIONAL SIZE, IN.	NUMBER	DIRECTION§	ULT. STRESS, PSI	YIELD STRESS,* PSI	ELONG. IN 2 IN. OR 4D, %	RED. OF AREA, %	YIELD STRESS,* PSI	ULT. STRESS, PSI	ULT. STRESS, PSI e/D=1.5	ULT. STRESS, PSI e/D=2.0	YIELD STRESS,† PSI e/D=1.5	YIELD STRESS,† PSI e/D=2.0
2X 9	341007	L	71 600	66 500	11.5	30	69 200	44 200	101 000	122 500	87 800	101 600
		LT	71 700	64 900	6.0	9	70 300	43 600	101 000	130 100	89 300	100 200
		ST	66 400	61 400	9.4	34	68 700	---	---	---	---	---
3X12	341008	L	71 900	66 200	10.5	28	68 400	42 200	102 300	132 500	89 800	107 300
		LT	71 000	65 100	7.5	12	69 800	41 800	97 100	126 800	88 600	108 200
		ST	69 700	62 200	5.0	7	69 700	41 300	---	---	---	---
4X 8	341009	L	70 300	64 200	12.5	29	66 400	40 400	89 300	123 700	85 500	103 000
		LT	69 900	63 000	7.5	12	65 100	40 600	90 700	121 700	87 200	102 100
		ST	66 900	59 500	2.5	4	69 300	39 900	---	---	---	---
4X16	341010	L										
		LT										
		ST							---	---	---	---
5X 5	341011	L	68 600	63 200	12.0	28	65 300	41 800	88 200	117 300	85 900	101 300
		LT	67 500	61 200	4.0	5	62 500	40 700	87 200	118 400	85 900	100 400
		ST	65 200	59 800	2.0	4	66 500	41 200	---	---	---	---
5X10	341012	L	68 800	61 600	11.5	27	63 000	40 600	93 400	117 400	82 700	94 800
		LT	67 300	60 200	5.5	9	61 700	40 300	88 700	123 400	83 600	99 000
		ST	64 600	57 400	3.0	6	65 300	38 700	---	---	---	---
5X20	341013	L	68 500	60 700	11.5	24	61 200	38 800	90 100	113 500	79 000	94 300
		LT	64 700	57 300	5.0	7	63 500	38 400	86 600	117 500	79 000	94 700
		ST	63 900	56 100	3.7	7	62 800	37 300	---	---	---	---
6X 6	341014	L	67 700	62 000	12.0	31	64 000	42 400	97 400	114 200	86 700	97 500
		LT	64 500	59 500	3.5	5	60 400	40 700	89 300	121 100	83 900	101 100
		ST	64 200	55 900	2.8	1	65 700	40 500	---	---	---	---
6X12	341015	L	66 200	59 500	11.0	27	60 300	40 200	91 100	120 100	81 600	96 100
		LT	64 200	56 400	3.5	6	61 900	39 800	87 700	119 000	80 600	98 800
		ST	63 900	55 900	3.5	2	61 900	38 700	---	---	---	---
6X24	341016	L	63 000	55 900	9.5	19	57 900	42 500	89 500	118 100	81 200	99 700
		LT	66 600	57 700	6.0	6	62 400	38 800	86 300	117 900	80 000	98 900
		ST	62 600	54 000	6.0	14	59 300	39 000	---	---	---	---

* OFFSET EQUALS 0.2 PER CENT
† OFFSET EQUALS 2.0 PER CENT OF PIN DIAMETER
‡ SPECIMENS AND FIXTURES CLEANED ULTRASONICALLY IN TOSON
§ L, LONGITUDINAL; LT, LONG TRANSVERSE; ST, SHORT TRANSVERSE

TABLE II

MECHANICAL PROPERTIES OF STRESS-RELIEVED 2024-T852 ALUMINUM ALLOY HAND FORGINGS

(F33615-68-C-1385)

SAMPLE			TENSILE				COMP.	SHEAR	BEARING EDGEWISE‡			
CROSS-SECTIONAL SIZE, IN.	NUMBER	DIREC-TION§	ULT. STRESS, PSI	YIELD STRESS,* PSI	ELONG. IN 2 IN. OR 4D, %	RED. OF AREA, %	YIELD STRESS,* PSI	ULT. STRESS, PSI	ULT. STRESS, PSI e/D=1.5	ULT. STRESS, PSI e/D=2.0	YIELD STRESS,† PSI e/D=1.5	YIELD STRESS,† PSI e/D=2.0
2x 8	341017	L	70 800	64 600	7.0	26	70 200	42 700	97 700	133 100	95 500	116 300
		LT	72 300	63 400	9.0	17	72 700	41 800	94 500	125 900	89 500	114 200
		ST	67 400	64 000	1.6	3	74 600	---	---	---	---	---
3x12	341018	L	72 200	66 700	5.5	18	70 000	42 400	94 900	123 400	93 700	109 300
		LT	73 700	69 000	3.0	2	67 900	42 000	94 500	126 100	93 500	113 300
		ST	68 100	64 400	1.0	2	72 200	40 200	---	---	---	---
4x 8	341019	L	68 900	61 100	9.0	26	62 200	40 500	91 900	117 900	82 500	100 500
		LT	70 400	63 200	5.0	8	62 500	39 500	88 800	119 400	82 800	101 000
		ST	65 700	57 200	3.2	4	65 500	38 600	---	---	---	---
4x16	341020	L	71 400	65 400	6.5	23	63 500	41 100	92 100	124 000	87 400	104 800
		LT	71 000	65 200	5.0	8	71 500	40 200	91 500	127 100	90 500	108 200
		ST	70 100	60 600	2.4	6	70 200	39 900	---	---	---	---
5x 5	341021	L	69 000	62 000	6.5	29	63 400	40 800	93 500	125 200	89 900	105 100
		LT	68 400	62 100	3.0	1	63 100	40 700	89 100	121 600	84 400	101 100
		ST	66 500	56 000	2.8	4	64 700	39 600	---	---	---	---
5x10	341022	L	68 400	61 000	4.5	25	63 000	40 300	89 100	114 300	87 700	96 800
		LT	69 100	61 500	6.0	8	64 800	39 700	89 500	120 200	85 100	99 600
		ST	66 100	59 900	1.5	4	68 400	38 800	---	---	---	---
5x20	341023	L	65 200	55 100	9.0	16	55 000	38 800	83 600	112 600	79 300	94 400
		LT	62 800	56 700	3.0	4	60 700	38 000	84 900	114 600	82 500	98 000
		ST	63 200	54 500	3.0	3	59 400	37 000	---	---	---	---
6x 6	341024	L	69 100	61 600	9.0	28	63 700	41 500	95 300	123 900	89 800	102 200
		LT	68 800	60 600	6.5	10	61 500	40 600	92 000	123 200	86 900	102 700
		ST	69 400	58 500	2.3	3	67 600	39 800	---	---	---	---
6x12	341025	L	67 000	58 700	8.0	22	59 700	39 600	84 700	117 100	82 400	100 500
		LT	67 400	60 200	3.2	4	63 500	38 400	85 700	113 400	81 400	95 700
		ST	65 300	55 100	2.9	3	63 000	37 400	---	---	---	---
6x24	341026	L	64 300	56 100	7.5	20	53 800					
		LT	65 400	57 800	5.0	8	57 500					
		ST	58 000	53 900	1.0	1	58 000		---	---	---	---

* OFFSET EQUALS 0.2 PER CENT
† OFFSET EQUALS 2.0 PER CENT OF PIN DIAMETER
‡ SPECIMENS AND FIXTURES CLEANED ULTRASONICALLY IN TOSON
§ L. LONGITUDINAL; LT. LONG TRANSVERSE; ST. SHORT TRANSVERSE

TABLE III

MECHANICAL PROPERTIES OF STRESS-RELIEVED 7075-T7352 ALUMINUM ALLOY HAND FORGINGS

(F33615-68-C-1385)

SAMPLE			TENSILE				COMP.	SHEAR	BEARING‡ EDGEWISE			
CROSS-SECTIONAL SIZE, IN.	NUMBER	DIREC-TION§	ULT. STRESS, PSI	YIELD STRESS,* PSI	ELONG. IN 2 IN. OR 4D, %	RED. OF AREA, %	YIELD STRESS,* PSI	ULT. STRESS, PSI	ULT. STRESS, PSI e/D=1.5	ULT. STRESS, PSI e/D=2.0	YIELD STRESS,† PSI e/D=1.5	YIELD STRESS,† PSI e/D=2.0
2X 8	341027	L	73 700	65 300	13.5	43	69 300	46 900	111 900	147 200	93 700	111 200
		LT	74 900	65 300	13.5	29	68 800	44 500	110 600	146 300	92 700	106 500
		ST	73 100	61 600	6.3	9	69 300	---	---	---	---	---
3X12	341028	L	76 400	66 200	11.5	27	66 900	42 400	103 100	136 100	89 000	103 800
		LT	71 400	59 300	8.0	11	65 300	42 600	98 300	135 100	89 800	110 300
		ST	73 000	60 800	4.2	5	69 300	42 900	---	---	---	---
4X 8	341029	L	68 400	57 300	15.0	42	60 200	39 800	95 100	130 000	83 500	98 600
		LT	65 100	53 000	10.0	17	57 600	38 400	98 500	127 100	81 400	99 000
		ST	64 500	50 400	6.4	10	57 500	38 200	---	---	---	---
4X16	341030	L	70 000	59 500	13.0	34	57 400	40 600	95 300	126 000	82 900	95 800
		LT	67 600	55 200	12.0	25	59 700	40 700	94 200	125 500	82 600	99 200
		ST	64 800	52 500	6.4	7	58 600	39 100	---	---	---	---
5X 5	341031	L	68 400	56 700	14.0	39	59 400	41 500	104 400	131 600	84 300	99 000
		LT	67 200	55 100	10.5	20	56 600	40 600	98 000	131 800	83 500	100 700
		ST	63 800	51 700	4.0	6	59 500	41 500	---	---	---	---
5X10	341032	L	65 200	52 700	14.0	37	53 400	39 600	95 900	124 600	82 300	91 900
		LT	64 000	51 400	9.0	17	53 800	38 500	97 700	127 100	80 100	97 000
		ST	64 200	49 500	7.0	9	58 000	39 400	---	---	---	---
5X20	341033	L	64 800	52 500	14.5	35	52 200	39 800	94 100	120 300	76 800	89 100
		LT	64 000	50 700	11.0	25	54 400	38 300	91 500	119 400	77 100	92 600
		ST	63 700	49 300	6.5	10	54 900	38 000	---	---	---	---
6X 6	341034	L	62 400	51 100	15.0	44	54 000	41 300	99 300	131 200	82 100	94 400
		LT	63 800	52 100	10.0	23	53 000	40 100	97 400	128 400	81 600	96 100
		ST	63 400	49 700	8.0	14	55 300	39 000	---	---	---	---
6X12	341035	L										
		LT										
		ST							---	---	---	---
6X24	341036	L										
		LT										
		ST							---	---	---	---

* OFFSET EQUALS 0.2 PER CENT
† OFFSET EQUALS 2.0 PER CENT OF PIN DIAMETER
‡ SPECIMENS AND FIXTURES CLEANED ULTRASONICALLY IN TOSON
§ L, LONGITUDINAL; LT, LONG TRANSVERSE; ST, SHORT TRANSVERSE

TABLE III

TABLE IV

TABLE IV

MECHANICAL PROPERTIES OF STRESS-RELIEVED 7079-T652 ALUMINUM ALLOY HAND FORGINGS

(F33615-68-C-1385)

SAMPLE			TENSILE				COMP.	SHEAR	BEARING‡			
									EDGEWISE			
									ULT. STRESS, PSI		YIELD STRESS, PSI†	
CROSS-SECTIONAL SIZE, IN.	NUMBER	DIRECTION§	ULT. STRESS, PSI	YIELD STRESS,* PSI	ELONG. IN 2 IN. OR 4D, %	RED. OF AREA, %	YIELD STRESS,* PSI	ULT. STRESS, PSI	e/D=1.5	e/D=2.0	e/D=1.5	e/D=2.0
2x8	341037	L	78 600	71 000	14.0	34	73 300	48 700	115 100	154 700	99 100	114 400
		LT	76 100	64 900	12.0	20	73 200	46 500	114 500	149 100	98 000	113 400
		ST	76 000	63 700	7.8	10	74 200	---	---	---	---	---
3x12	341038	L	77 500	68 700	13.0	26	71 300	46 400	113 200	148 800	94 800	112 900
		LT	76 100	65 700	12.0	26	70 700	46 100	116 600	149 100	97 900	114 600
		ST	73 700	61 400	8.0	11	71 800	45 400	---	---	---	---
4x8	341039	L	78 800	69 600	11.0	21	72 800	48 900	111 600	148 300	99 400	115 200
		LT	77 500	66 500	11.5	24	72 900	48 200	117 100	148 700	102 300	117 200
		ST	74 300	62 800	5.0	6	73 200	47 300	---	---	---	---
4x16	341040	L	77 900	68 000	12.0	22	70 100	46 600	113 000	145 900	95 200	110 300
		LT	74 600	63 000	9.5	18	66 800	45 700	107 500	144 400	94 000	105 700
		ST	74 000	62 900	7.9	17	70 600	44 900	---	---	---	---
5x5	341041	L	75 600	67 600	13.0	27	69 700	47 900	112 600	149 900	94 400	108 900
		LT	72 900	63 000	8.5	12	67 000	45 900	105 200	143 600	92 100	107 600
		ST	71 300	59 500	7.0	10	68 400	46 300	---	---	---	---
5x10	341042	L	76 100	68 000	13.0	27	68 800	45 700	108 200	140 900	92 800	107 000
		LT	74 100	62 400	10.5	19	69 300	45 900	108 300	141 300	94 300	109 100
		ST	73 000	61 300	5.5	5	72 200	44 400	---	---	---	---
5x20	341043	L	76 900	65 600	13.0	24	67 000	46 200	104 600	135 900	91 800	106 400
		LT	73 300	61 400	11.0	19	65 700	46 400	103 300	136 900	89 800	105 400
		ST	71 300	58 300	6.0	7	68 300	44 000	---	---	---	---
6x6	341044	L	73 600	63 800	15.0	37	68 900	48 400	112 200	148 100	95 600	105 400
		LT	72 600	61 400	9.0	16	69 700	47 900	111 000	146 000	96 700	109 400
		ST	71 700	61 800	8.5	14	67 100	47 300	---	---	---	---
6x12	341045	L	75 200	65 700	11.0	25	67 500	46 300	109 000	139 300	93 800	107 500
		LT	72 800	62 100	7.5	12	66 200	45 500	104 000	140 700	92 300	107 600
		ST	72 400	58 800	6.0	7	69 300	44 700	---	---	---	---
6x24	341046	L	73 900	63 900	12.0	22	63 300	43 800				
		LT	69 100	57 500	10.0	22	62 900	42 000				
		ST	69 300	58 100	4.5	6	67 300	42 000	---	---	---	---

* OFFSET EQUALS 0.2 PER CENT
† OFFSET EQUALS 2.0 PER CENT OF PIN DIAMETER
‡ SPECIMENS AND FIXTURES CLEANED ULTRASONICALLY IN TOSON
§ L, LONGITUDINAL; LT, LONG TRANSVERSE; ST, SHORT TRANSVERSE

TABLE V

RATIOS AMONG THE TENSILE, COMPRESSIVE, SHEAR AND BEARING PROPERTIES
OF STRESS-RELIEVED ALUMINUM ALLOY HAND FORGINGS
(F33615-68-C-1385)

ALLOY AND TEMPER	SAMPLE CROSS SECT. SIZE, IN.	SAMPLE NUMBER	CYS(L)/TYS(L)	CYS(LT)/TYS(LT)	CYS(ST)/TYS(ST)	SS(L)/TS(LT)	SS(LT)/TS(LT)	SS(ST)/TS(LT)	EDGEWISE BS(L)/TS(LT) e/D= 1.5	EDGEWISE BS(L)/TS(LT) e/D= 2.0	EDGEWISE BYS(L)/TYS(LT) e/D= 1.5	EDGEWISE BYS(L)/TYS(LT) e/D= 2.0	EDGEWISE BS(LT)/TS(LT) e/D= 1.5	EDGEWISE BS(LT)/TS(LT) e/D= 2.0	EDGEWISE BYS(LT)/TYS(LT) e/D= 1.5	EDGEWISE BYS(LT)/TYS(LT) e/D= 2.0
2014-T652	2X 8	341007	1.04	1.08	1.12	0.62	0.61	---	1.41	1.71	1.35	1.56	1.41	1.81	1.38	1.54
	3X12	341008	1.03	1.07	1.12	0.59	0.59	0.58	1.44	1.87	1.38	1.65	1.37	1.78	1.36	1.66
	4X 8	341009	1.03	1.03	1.17	0.58	0.58	0.57	1.28	1.77	1.36	1.63	1.30	1.74	1.38	1.62
	4X16	341010														
	5X 5	341011	1.03	1.02	1.13	0.62	0.60	0.61	1.31	1.74	1.40	1.65	1.29	1.75	1.40	1.64
	5X10	341012	1.02	1.02	1.14	0.60	0.60	0.57	1.39	1.74	1.37	1.57	1.32	1.83	1.39	1.64
	5X20	341013	1.01	1.11	1.12	0.60	0.59	0.58	1.39	1.75	1.38	1.65	1.34	1.82	1.38	1.65
	6X 6	341014	1.03	1.02	1.18	0.65	0.63	0.62	1.50	1.76	1.46	1.64	1.34	1.87	1.41	1.70
	6X12	341015	1.01	1.06	1.12	0.63	0.60	0.60	1.42	1.87	1.40	1.64	1.37	1.85	1.36	1.69
	6X24	341016	1.04	1.08	1.10	0.64	0.58	0.59	1.34	1.77	1.41	1.73	1.30	1.77	1.39	1.71
2024-T852	2X 8	341017	1.09	1.14	1.17	0.59	0.58	---	1.35	1.84	1.50	1.82	1.31	1.74	1.40	1.79
	3X12	341018	1.05	0.98	1.12	0.58	0.57	0.55	1.29	1.67	1.36	1.58	1.28	1.71	1.36	1.64
	4X 8	341019	1.02	0.99	1.15	0.58	0.56	0.55	1.30	1.67	1.31	1.59	1.26	1.70	1.31	1.60
	4X16	341020	0.97	1.10	1.16	0.58	0.57	0.56	1.30	1.74	1.34	1.61	1.29	1.79	1.39	1.66
	5X 5	341021	1.02	1.02	1.15	0.60	0.59	0.58	1.37	1.83	1.45	1.69	1.30	1.78	1.36	1.63
	5X10	341022	1.03	1.05	1.14	0.58	0.57	0.56	1.29	1.65	1.43	1.57	1.29	1.74	1.39	1.62
	5X20	341023	1.00	1.07	1.09	0.62	0.61	0.59	1.33	1.79	1.40	1.67	1.35	1.83	1.46	1.73
	6X 6	341024	1.03	1.01	1.16	0.60	0.59	0.58	1.39	1.80	1.48	1.69	1.34	1.79	1.43	1.64
	6X12	341025	1.02	1.06	1.14	0.59	0.57	0.56	1.26	1.74	1.37	1.67	1.27	1.66	1.35	1.59
	6X24	341026	0.96	0.99	1.08											
7075-T7352	2X 8	341027	1.06	1.05	1.12	0.62	0.59	---	1.49	1.96	1.44	1.70	1.48	1.95	1.42	1.63
	3X12	341028	1.01	1.10	1.14	0.59	0.60	0.60	1.44	1.91	1.50	1.75	1.34	1.89	1.51	1.86
	4X 8	341029	1.05	1.09	1.14	0.61	0.59	0.59	1.46	2.00	1.58	1.86	1.51	1.95	1.54	1.87
	4X16	341030	0.96	1.08	1.12	0.60	0.60	0.58	1.41	1.86	1.50	1.73	1.39	1.86	1.57	1.80
	5X 5	341031	1.05	1.03	1.15	0.62	0.60	0.62	1.55	1.96	1.53	1.79	1.46	1.96	1.51	1.83
	5X10	341032	1.01	1.05	1.17	0.62	0.60	0.62	1.50	1.95	1.60	1.70	1.43	1.93	1.56	1.89
	5X20	341033	1.00	1.07	1.11	0.61	0.60	0.59	1.47	1.88	1.51	1.76	1.43	1.86	1.52	1.83
	6X 6	341034	1.06	1.02	1.11	0.65	0.63	0.61	1.56	2.06	1.58	1.81	1.53	2.01	1.57	1.84
	6X12	341035														
	6X24	341036														
7079-T652	2X 8	341037	1.03	1.13	1.17	0.64	0.61	---	1.51	2.03	1.53	1.76	1.50	1.96	1.51	1.75
	3X12	341038	1.04	1.08	1.17	0.61	0.61	0.60	1.49	1.95	1.44	1.72	1.53	1.96	1.49	1.74
	4X 8	341039	1.05	1.10	1.16	0.63	0.62	0.61	1.44	1.91	1.50	1.73	1.51	1.92	1.54	1.76
	4X16	341040	1.03	1.06	1.12	0.62	0.61	0.60	1.52	1.96	1.51	1.75	1.44	1.94	1.49	1.68
	5X 5	341041	1.03	1.06	1.15	0.66	0.63	0.64	1.54	2.06	1.50	1.73	1.44	1.97	1.46	1.71
	5X10	341042	1.01	1.11	1.18	0.62	0.62	0.60	1.46	1.90	1.48	1.71	1.46	1.91	1.52	1.74
	5X20	341043	1.02	1.07	1.17	0.63	0.63	0.60	1.43	1.85	1.50	1.73	1.41	1.87	1.46	1.72
	6X 6	341044	1.08	1.14	1.09	0.67	0.66	0.65	1.55	2.04	1.56	1.72	1.53	2.01	1.59	1.74
	6X12	341045	1.03	1.07	1.19	0.64	0.63	0.61	1.50	1.91	1.51	1.73	1.43	1.93	1.49	1.73
	6X24	341046	0.99	1.09	1.16	0.63	0.61	0.61								

TABLE V

TABLE VI

SPECIFIED MINIMUM VALUES FOR ALUMINUM ALLOY HAND FORGINGS
(F33615-68-C-1385)

Alloy and Temper	Thickness, in.	Longitudinal Tensile Strength, psi	Longitudinal Yield Strength,* psi	Longitudinal Elong. in 4D, %	Long-Transverse Tensile Strength, psi	Long-Transverse Yield Strength,* psi	Long-Transverse Elong. in 4D, %	Short-Transverse Tensile Strength, psi	Short-Transverse Yield Strength,* psi	Short-Transverse Elong. in 4D, %	Federal Specification
2014-T652	Up thru 2.000	65 000	56 000	8	65 000	56 000	3	---	---	-	QQ-A-367g
	2.001-3.000	64 000	56 000	8	64 000	55 000	3	62 000	52 000	2	
	3.001-4.000	63 000	55 000	8	63 000	55 000	3	61 000	51 000	2	
	4.001-5.000	62 000	54 000	7	62 000	54 000	2	60 000	50 000	1	
	5.001-6.000	61 000	53 000	7	61 000	53 000	2	59 000	50 000	1	
2024-T352	All	---	---	-	---	---	-	---	---	-	None
7075-T7352	Up thru 3.000	66 000	54 000	7	64 000	52 000	4	61 000	50 000	3	None**
	3.001-4.000	64 000	53 000	7	63 000	50 000	3	60 000	49 000	2	
	4.001-5.000	62 000	51 000	7	61 000	48 000	3	58 000	46 000	2	
	5.001-6.000	61 000	49 000	6	59 000	45 000	3	57 000	44 000	2	
7079-T652	Up thru 2.000	72 000	63 000	9	71 000	61 000	5	---	---	-	QQ-A-367g
	2.001-3.000	72 000	62 000	9	70 000	60 000	5	67 000	55 000	3	
	3.001-4.000	71 000	61 000	9	70 000	59 000	5	67 000	55 000	3	
	4.001-5.000	70 000	60 000	9	69 000	55 000	4	66 000	54 000	3	
	5.001-6.000	69 000	59 000	9	68 000	56 000	4	66 000	53 000	3	

* Offset equals 0.2 per cent.
** The Aluminum Association, "Aluminum Standards and Data", April 1968.

TABLE VI

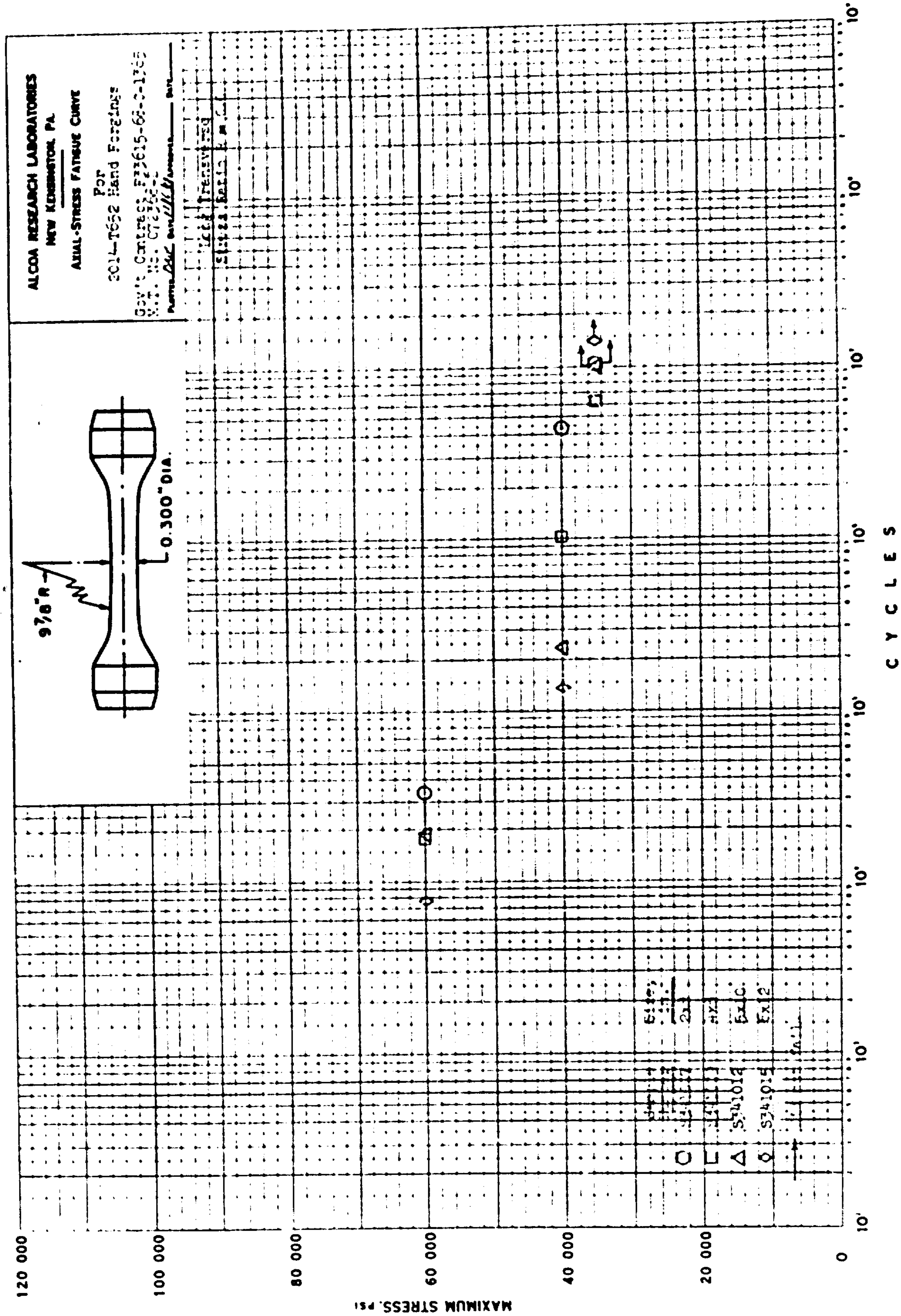

ALCOA RESEARCH LABORATORIES
NEW KENSINGTON, PA.
AXIAL-STRESS FATIGUE CURVE
For
Hand Forgings
0.300" DIA.
CYCLES
MAXIMUM STRESS, PSI
120 000
100 000
80 000
60 000
40 000
20 000
0

Fig. 1

Fig. 1

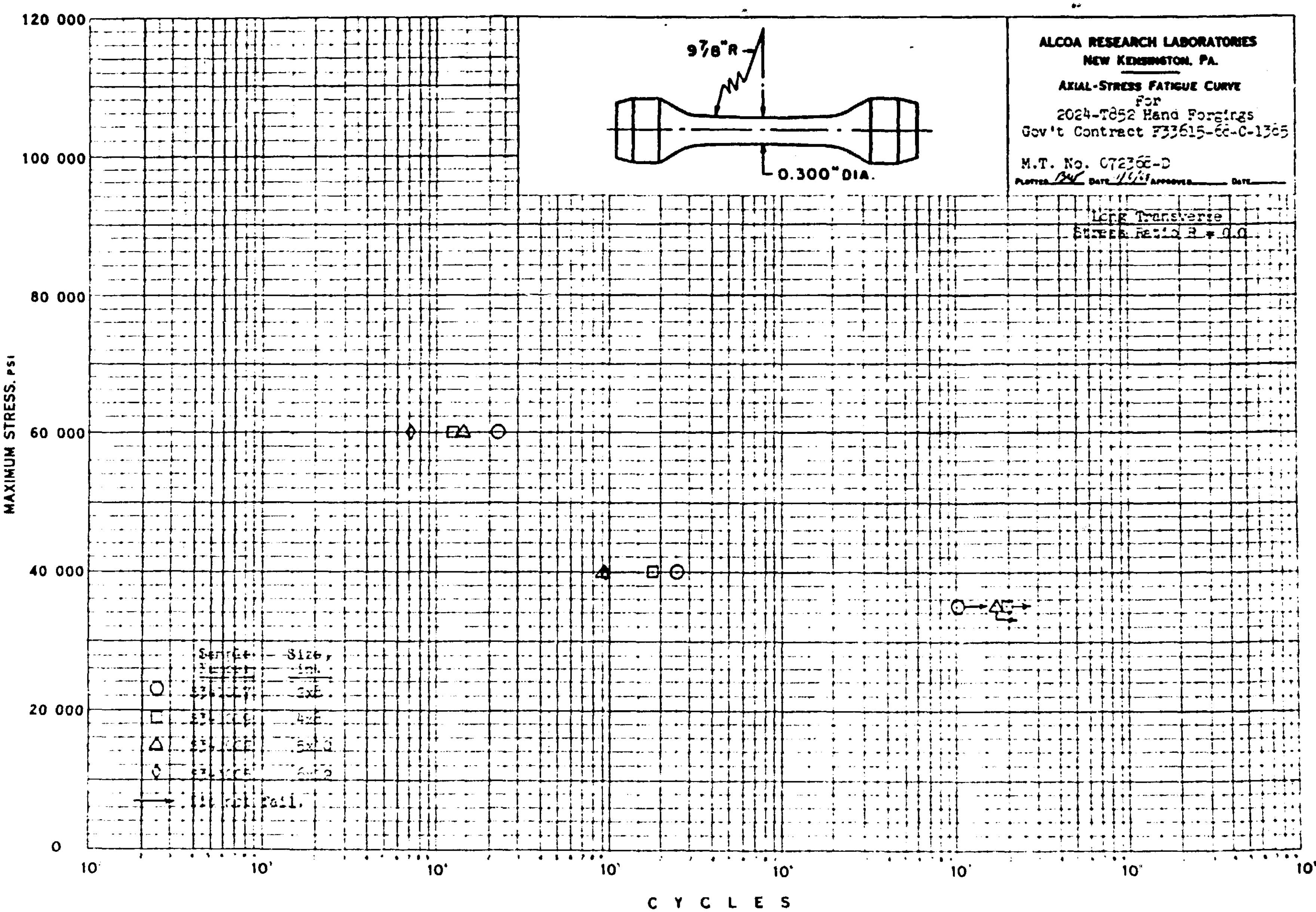

ALCOA RESEARCH LABORATORIES
NEW KENSINGTON, PA.
AXIAL-STRESS FATIGUE CURVE
For
2024-T852 Hand Forgings
Gov't Contract F33615-66-C-1365
M.T. No. 072366-D
Long Transverse
Stress Ratio R = 0.0
9 7/8" R
0.300" DIA.
MAXIMUM STRESS, PSI
120 000
100 000
80 000
60 000
40 000
20 000
0
CYCLES

Fig. 2

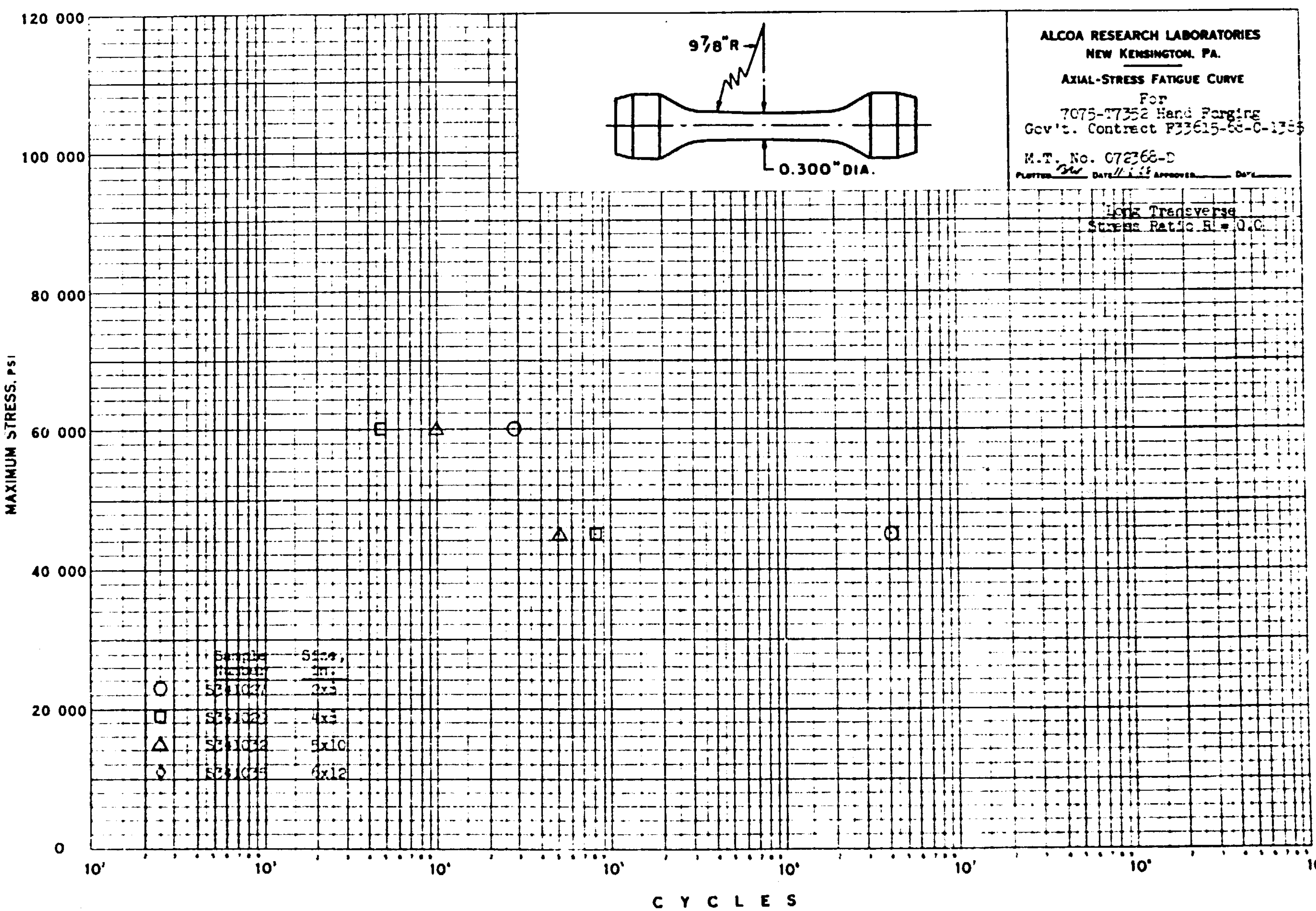
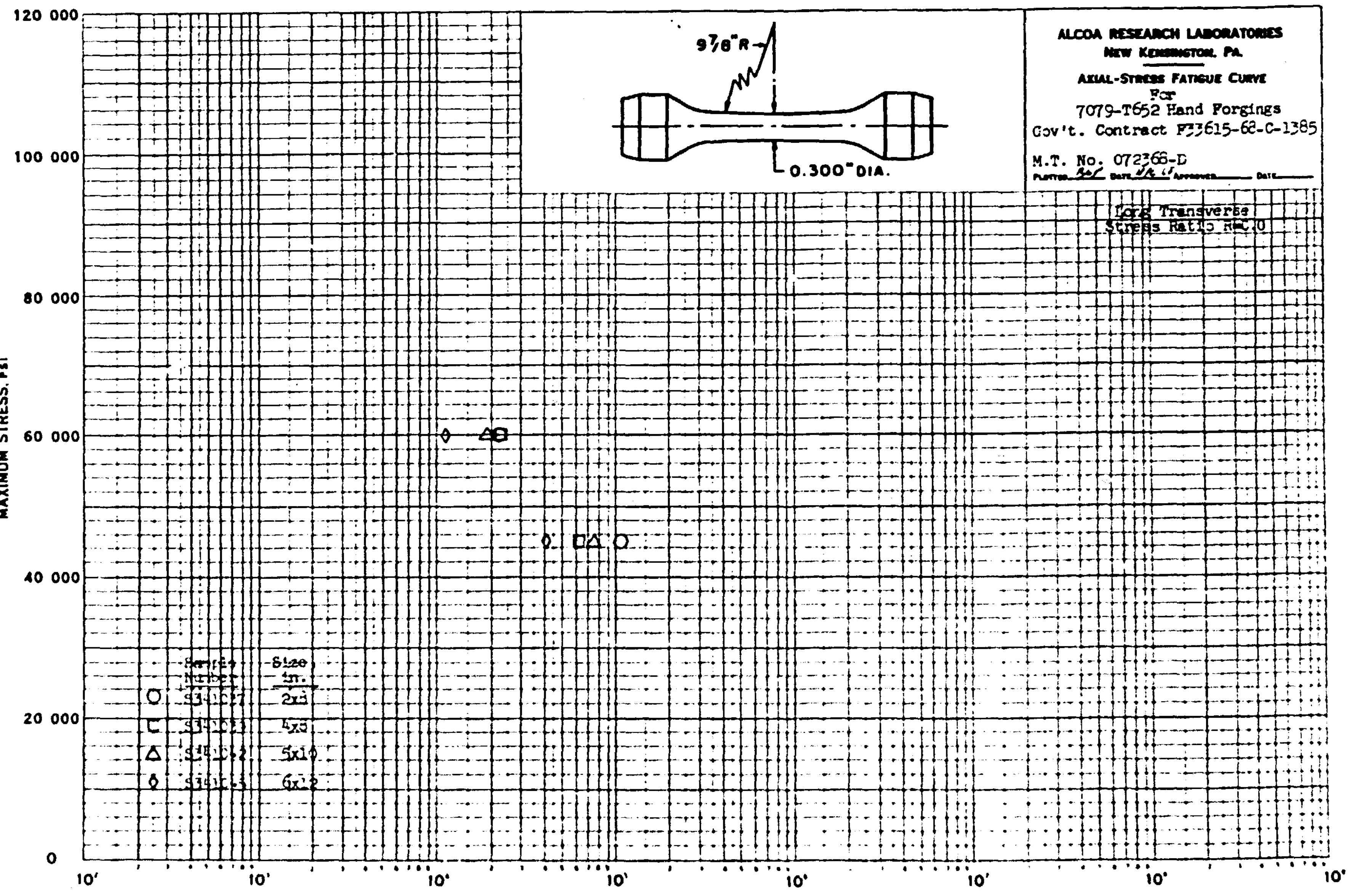

ALCOA RESEARCH LABORATORIES
NEW KENSINGTON, PA.
AXIAL-STRESS FATIGUE CURVE
For
7075-T7352 Hand Forging
M.T. No. 072368-D
Long Transverse
9 7/8" R
0.300" DIA.
MAXIMUM STRESS, PSI
120 000
100 000
80 000
60 000
40 000
20 000
0
Size, in.
5x10
6x12
C Y C L E S

Fig. 3

Fig. 3



ALCOA RESEARCH LABORATORIES
NEW KENSINGTON, PA.
AXIAL-STRESS FATIGUE CURVE
For
7079-T652 Hand Forgings
Gov't. Contract F33615-68-C-1385
M.T. No. 072366-D
Long Transverse
9 7/8" R
0.300" DIA.
120 000
100 000
80 000
60 000
40 000
20 000
0
MAXIMUM STRESS, PSI
Size
in.
2x8
4x8
5x10
6x12
C Y C L E S

Fig. 4